FLUORSPAR MINING METHODS AND COSTS, OZARK-MAHONING CO., HARDIN COUNTY, ILL.

By Harold Bailie, E. Powell, William Melcher,
and F. J. Myslinski

* * * * * * * * * * * * information circular 7984

UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary

BUREAU OF MINES
Marling J. Ankeny, Director

Generated on 2024-09-22 02:51 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from
THE OHIO STATE UNIVERSITY

This publication has been cataloged as follows:

Bailie, Harold

Fluorspar mining methods and costs, Ozark-Mahoning Co., Hardin County, Ill., by Harold Bailie [and others] [Washington] U.S. Dept. of the Interior, Bureau of Mines [1960]

ii, 33 p. illus., tables. 27 cm. (U.S. Bureau of Mines. Information circular 7984)

Bibliographical footnotes.

1. Fluorspar. I. Ozark-Mahoning Co. (Series)

[TN23.U71 no. 7984] 622.06173

U.S. Dept. of the Int. Library

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 30 cents

Generated on 2024-09-22 02:49 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

Original from
THE OHIO STATE UNIVERSITY

CONTENTS

	Page
Introduction and summary	1
Acknowledgments	2
History	2
Description of deposits	3
Methods of prospecting and exploration	4
Methods of sampling	4
Tonnages and values	6
Mine development practices	6
Shaft sinking	6
Crosscutting and drifting	10
Stoping methods	12
Drilling and blasting	13
Methods of ground support	15
Loading	16
Underground transportation	19
Auxiliary operations	21
Compressor plant	22
Ore handling on the surface	22
Surface facilities	24
Power	25
Percentage extraction and production rates	26
Mining methods in Cave-in-Rock area	27
Ventilation	27
Mine drainage	28
Wages and incentive programs	29
Fire prevention	31
Safety practices	31
Summary of costs	32

ILLUSTRATIONS

Fig.		
1.	Location map, Ozark-Mahoning Co. mines, Hardin County, Ill	3
2.	Plan map of North Green underground workings	5
3.	Plan view of Hill-Ledford three-compartment shaft	7
4.	Typical wooden headframe	8
5.	Typical 7- by 7-foot crosscut round	10
6.	Typical mine-car hoisting cage	12
7.	Typical airleg drill in operation	13
8.	Typical stope blasting round	14
9.	Method of roof bolting relatively thin layers of roof rock	16
10.	Using a truck bed as a platform to bolt a high back	17
11.	Typical crawler-mounted slusher ramp	18
12.	Typical pneumatic-tire-mounted slusher ramp	18
13.	Trackless overhead loader in operation	19

Generated on 2024-09-22 02:54 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

ILLUSTRATIONS (Con.)

Fig.		Page
14.	Diesel locomotive used in a track haulage system....	19
15.	Typical haulage truck used underground.....	20
16.	Hill-Ledford grizzly at mining level.....	22
17.	Primary crushing and loading unit at Hill-Ledford mine.....	23
18.	Compressor-plant installation which includes a water softener.....	24
19.	Headframe constructed of 4-inch API rotary drill pipe.....	25
20.	Hoisting facilities at Hill-Ledford mine.....	26
21.	Fan installation at mining level of North Green mine.....	28
22.	Ventilation tube used at Hill-Ledford mine.....	29

TABLES

1.	Summary of costs, percent of total.....	32
2.	Summary of costs in units of labor, power, and supplies.....	33

Generated on 2024-09-22 02:51 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

FLUORSPAR MINING METHODS AND COSTS, OZARK-MAHONING CO., HARDIN COUNTY, ILL.[1]

by

Harold Bailie,[2] Ed Powell,[3] William Melcher,[4] Frank J. Myslinski[5]

INTRODUCTION AND SUMMARY

The purpose of this Bureau of Mines report is to furnish information on mining practices applied to flat-bedded fluorspar deposits in southern Illinois. It presents new and improved operating procedures and specialized techniques applicable to deposits of this type.

All of the operating mines of the Ozark-Mahoning Co. in this area have been opened by vertical shafts which connect with levels consisting of haulage ways, stopes, and loading stations. The stoping practice used locally called room and pillar, is open stoping with pillars left at different distances and diameters. To facilitate haulage and drainage, the mines are worked from openings turned off the main haulage drift on a grade to conform with the dip of the ore beds.

The ore is predominantly fluorspar with smaller amounts of galena and sphalerite that contain traces of cadmium and germanium. The principal gangue minerals are limestone, calcite, shale, barite, and sandstone. The rock hardness ranges from relatively soft shale to hard, abrasive sandstone.

Mechanized equipment, such as airleg drills, scrapers, overshot and end loaders, belt conveyors, diesel trucks, and locomotive haulage units, is used to mine these deposits efficiently and economically and to improve recovery, safety, and efficiency. Consequently the mining cost has not risen despite the upward trend of labor and supply costs.

The Ozark-Mahoning Co. is one of several large operators mining and milling fluorspar in the southern Illinois fluorspar district. This report is limited to the company's operations in the Cave-in-Rock area, which are confined to the flat-bedded replacement deposits common to the Cave-in-Rock

---

1/ Work on manuscript completed December 1959.
2/ General superintendent, Ozark-Mahoning Co., Rosiclare, Ill.
3/ Superintendent of mines, Ozark-Mahoning Co.
4/ Assistant mine superintendent, Rosiclare operation, Ozark-Mahoning Co.
5/ Mining engineer, Bureau of Mines, Region V, College Park, Md.

Generated on 2024-09-22 02:54 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

area. The Ozark-Mahoning Co. also purchases or custom-mills ore from small operators whose facilities are inadequate for beneficiating ore with a high lead and zinc content.

The current methods and equipment used to mine the flat-bedded deposits have been developed from many tests and time studies conducted since the deposits were discovered. Raymond B. Ladoo made an extensive study[6] of this area between 1921 and early 1923. At that time the open-stope method of mining was used predominantly. Although somewhat modified, it is still the accepted mining method in the area. At the time of Ladoo's study, drilling was done with light jackhammer drills mounted on arms from steel columns or used with breast boards. Blasted ore was shoveled by hand into mine cars and trammed by hand or mules to shaft stations or through an adit. In areas where the roof was weak, timber props were used. Ventilation was then a serious problem. A study of Ozark-Mahoning Co.'s mechanics of mining practices in this area indicates that the company's operating mines in the Cave-in-Rock area now use more modern methods of production.

This report describes the shaft-sinking practices at the Hill-Ledford mine, crosscutting methods at the Oxford mine, and mining procedures and ore flow at the North Green and Hill-Ledford mines.

ACKNOWLEDGMENTS

The authors wish to thank A. G. Johnson, general manager, E. A. Brecke, C. W. Tandy, and the entire staff of the Ozark-Mahoning Co., Mahoning Mining Division, for their cooperation in supplying information and permitting access to their mines.

HISTORY

Mining was begun in the Cave-in-Rock area about 1850, when the ore was mined for its galena and fluorspar was considered gangue. By 1870, important uses had been developed for fluorspar. Actual mining of fluorspar started about 1900. However, large-scale mining did not begin until after World War I Fluorspar mining was confined to vein-type deposits until the early 1920's, when the first flat-bedded replacement deposit was opened in the Cave-in-Rock area.[7]

The Mahoning Mining Co. began exploratory drilling on optioned land in T. 11 S., R. 9 E., Hardin County, Ill. The drilling located several large deposits that could be mined economically. In 1939, the company sank shafts to the W. L. Davis-Deardorff and A. L. Davis ore bodies. In June 1939 the company opened a mill in Rosiclare, Ill., to mill ore from these mines and jig tailings purchased from small operators of vein-type deposits in the area.

6/ Ladoo, R. B., Fluorspar: Its Mining, Milling, and Utilization, with a chapter on Cryolite: Bureau of Mines Bull. 244, 1927, pp. 95-100.

7/ Weller, J. M., Grogan, R. M., and Tippie, F. E., with contributions by Workman, L. E., and Sutton, A. H., Geology of the Fluorspar Deposits of Illinois: Ill. Geol. Surv. Bull. 76, 1952, 147 pp.

Generated on 2024-09-22 02:47 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

In 1942 the company opened the West Green mine, in 1943 the East Green mine, and in 1945 the W. L. Davis No. 2 mine. In December 1946 Mahoning Mining Co. became the Ozark-Mahoning Co., Mahoning Mining Division. The North Green mine was opened in 1949, the A. L. Davis No. 16 and Edgar Davis mines in 1951, the S. E. Oxford mine in 1953, and the Hill-Ledford mine in 1957. (See fig. 1.)

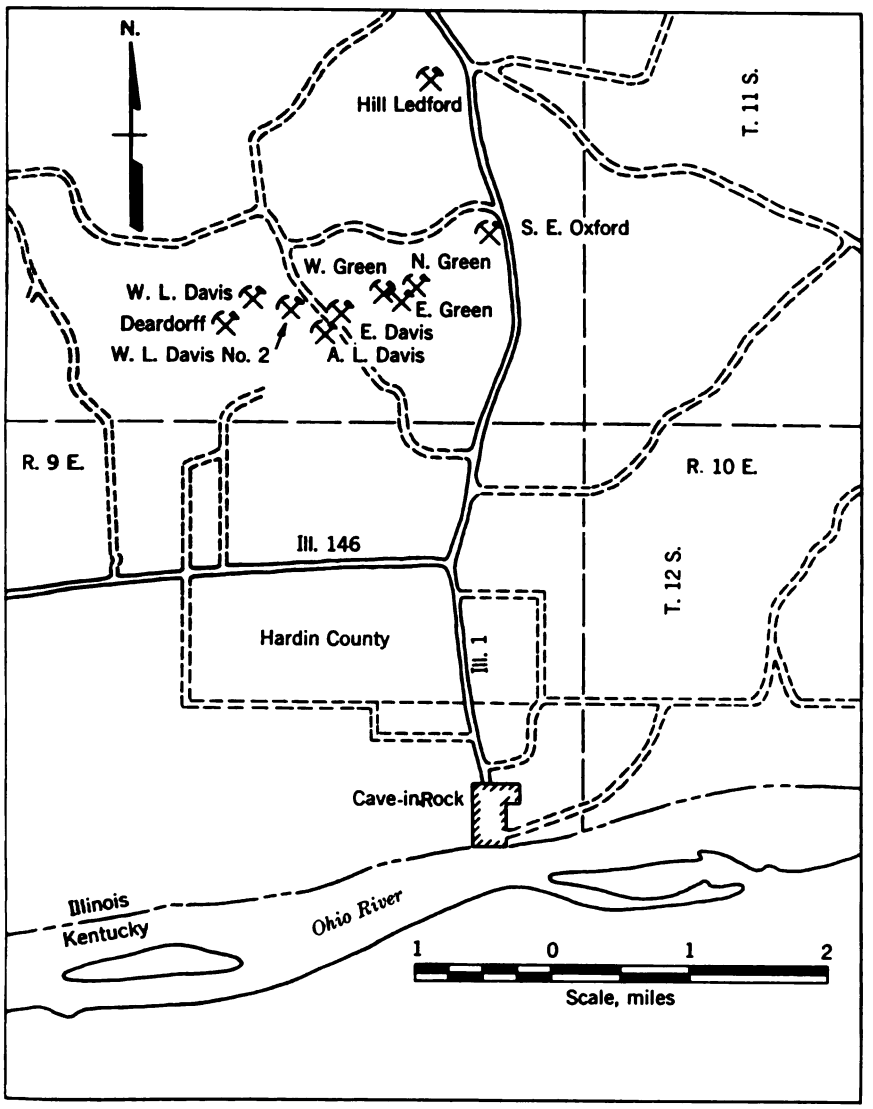

FIGURE 1. - Location Map, Ozark-Mahoning Co. Mines, Hardin County, Ill.

DESCRIPTION OF DEPOSITS[8]

The Cave-in-Rock fluorspar deposits in eastern Hardin County, Ill., are bedded-replacement deposits that occur in limestone of Mississipian age. The ore occupies either the Fredonia, Levias or Renault limestone formations.

This district lies approximately one-half mile southeast of a major fault zone known as the Peters Creek fault and encompasses an area of about 7 square miles. The mineralized area trends N. 50° E. and dips 2 1/2° N. to NE. The mineralized area is cut by numerous small faults and fractures which control the trends of mineralization. The most common strike directions are N. 50° E. and N. 40° W. with lo local variations. The ore bodies along these faults average about 125 feet wide and 9 1/2 feet thick. The length ranges from a few hundred to several thousand feet. The roof of the deposit may be shale, sandstone, or limestone of varying thickness. The bottom is generally a dense, dark-colored limestone. The deposits lie along one or

8/ Work cited in footnote 7.

Generated on 2024-09-22 02:50 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

both sides of minor faults and have long, narrow outlines which are lenticular or wedge shape in cross section. The faults have small displacements ranging from 1 to 20 feet.

The predominant minerals, fluorspar, barite, sphalerite, and galena, vary in grade and tenor at each deposit. The ore has been found as outcrops and at depths up to 1,000 feet.

METHODS OF PROSPECTING AND EXPLORATION

Early prospectors favored sinking shallow shafts, test pits, and trenches to find an ore body. These practices were adequate at the time because ore outcrops were numerous. However, when outcrops became more difficult to find, other methods were needed to probe for buried ore. Prospecting with churn and diamond drills was adopted to supplement and, at times, replace shallow pit and trench testing. The use of churn drills eventually became more common, because they drill a large-diameter hole which can be used later as an air course for ventilating stopes. They also provide a sample that covers a relatively large cross section of the penetrated rock formations. Core drilling has not proved satisfactory in fractured ground. It is more expensive than churn drilling, and the sample obtained is smaller and less representative. Electrical self-potential and soil-sampling prospecting methods have been tried and found inadequate either in supplementing or guiding a drilling program.

When exploratory drilling is done from the surface, drill holes are spaced at 200-foot intervals for depths of 800 feet or less at 300-foot intervals for greater depths. Drilling is usually along the strike of or roughly parallel to proven ore bodies. The first line of holes is drilled to find ore and to obtain information on the geologic structure. When ore is found, detailed drilling to outline the ore body proceeds by spacing holes as required at 100- to 150-foot centers or less. At this time, fences of holes are also drilled across the dip of the structure, at intervals ranging from 50 to 100 feet, to obtain cross sections of the mineralized area. A discovery is drilled sufficiently to obtain full and accurate information for estimating ore reserves and the nature of the surrounding waste rock. (See fig. 2.)

Underground prospecting from mined-out stopes, using diamond drills and percussion drills with sectional steel rods and tungsten carbide detachable chisel bits, supplements surface churn drilling in locating and outlining additional ore.

Any work other than stoping performed during and after shaft sinking is considered development, which includes drifting (in waste), crosscutting and underground prospecting with diamond and percussion drills.

METHOD OF SAMPLING

Newly discovered ore horizons are sampled by churn drilling. However, after the ore body has been developed, diamond core and percussion drilling units are used underground to obtain representative samples of rock that has not been delimited by drilling from the surface.

Generated on 2024-09-22 02:44 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

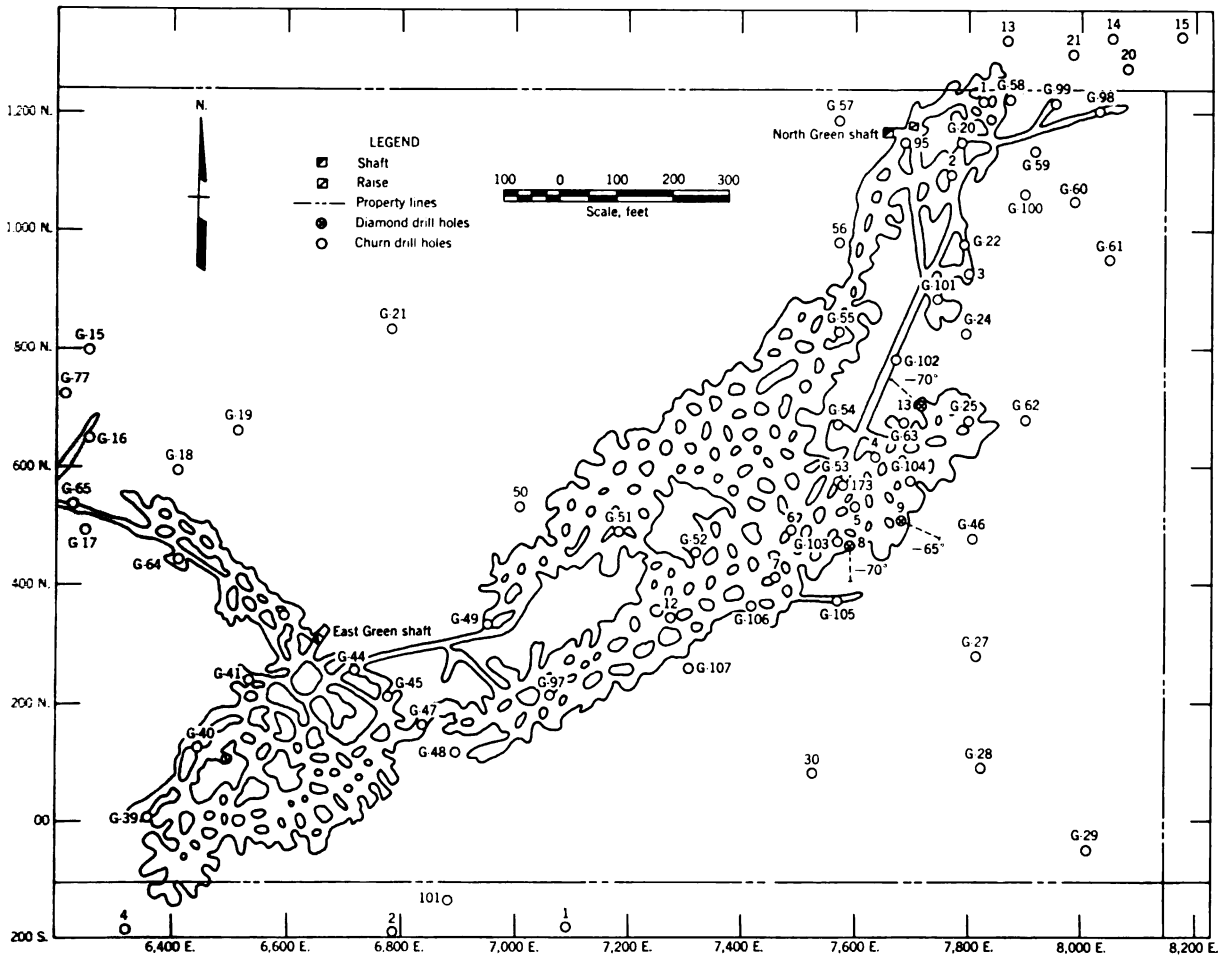

FIGURE 2. - Plan Map of North Green Underground Workings.

Churn-drill holes are sampled at 5-foot intervals in barren rock and at 2 1/2-foot intervals when there is a show of mineralization to determine the thickness of the ore. Representative samples taken at the measured intervals are carefully studied by the geologist, who logs the hole and checks the samples for the presence of minerals. He then determines which samples are to be assayed at the company's laboratory at Rosiclare, Ill.

Core recovered from underground diamond-drill holes is placed in core boxes and sent to the geologist for examination and logging. Sections of core showing traces of ore are split and assayed.

Representative samples of long-hole percussion drill cuttings are taken at measured intervals and bagged. Although these samples usually are not assayed, carful geologic studies are made to detect the presence of minerals which could indicate the existence of ore shoots behind waste rock.

574790 O–60–2

Generated on 2024-09-22 02:53 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TONNAGES AND VALUES

When an adequate surface drilling program is completed, tonnages and values are calculated to determine if enough ore has been found to justify development. This calculation is made from drill-hole data plotted in plan and section. The volume is determined by actual scale measurements on these drawings; the values are determined by the weighted average of the assays. The possible limiting area of influence of a hole is determined by personal judgment based on experience obtained in this district. The tonnage of the ore body is determined from the computed volume using a factor of 12 cubic feet per ton of ore in place. This factor has been found to be the average for the ore-bearing rock in southern Illinois. The tonnages are then adjusted to exclude ore that will be left as pillars or is considered too dangerous to mine.

MINE DEVELOPMENT PRACTICES

The ore bodies are developed in various combinations at each of Ozark-Mahoning's mines in this area. Access to the deposits is by vertical shafts. Development of the ore body after sinking a shaft is controlled by the stoping method, selected from a study of data assembled from the surface drilling program. Shafts generally are sunk to predetermined depth outside the boundaries of the mineralized area. Crosscuts are then driven to the ore body. Dimensions of the crosscuts depend on the operating clearance necessary for the equipment used in the mining method. The shaft sinking and crosscutting practices used at the Hill-Ledford and Oxford No. 11 mines are presented to illustrate practices favored by the company.

Shaft Sinking

The Hill-Ledford mine, located in secs. 23 and 24, T. 11 S., R. 9 E., Hardin County, Ill., about 6 miles north of Cave-in-Rock, Ill., was explored by churn drilling. Results of exploration indicated sufficient reserves of minable ore to warrant development of the deposit. The mine was developed by three-compartment vertical shaft 6 by 15 feet inside the timbered sets and 804 feet deep. Ths shaft is divided into two combination man and skip compartments and a service-manway-ventilation compartment, as shown in figure 3.

Preparatory to shaft sinking, a shaft site was chosen and tested by churn drilling to its calculated depth. Test holes indicated 40 feet of overburden underlaid by strata of shale, sandstone, and limestone of varying thicknesses. The existence of a water table above the ore horizon was also indicated. To avoid a serious influx of water while sinking the shaft, the water table was lowered below the proposed mining level by a submersible deep-well pump with a discharge capacity of 250 g.p.m. at an 800-foot head. This pump was lowered into 840-foot, 10-inch-diameter churn-drill hole which penetrated a water-bearing crevice that acted as a drain for the entire ore body.

The Hill-Ledford shaft sinking operation began in July 1953. A clamshell excavator combined with truck haulage was used to excavate 40 feet of overburden consisting of top soil, dark shale, and sandstone. The excavated part

Generated on 2024-09-22 02:54 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

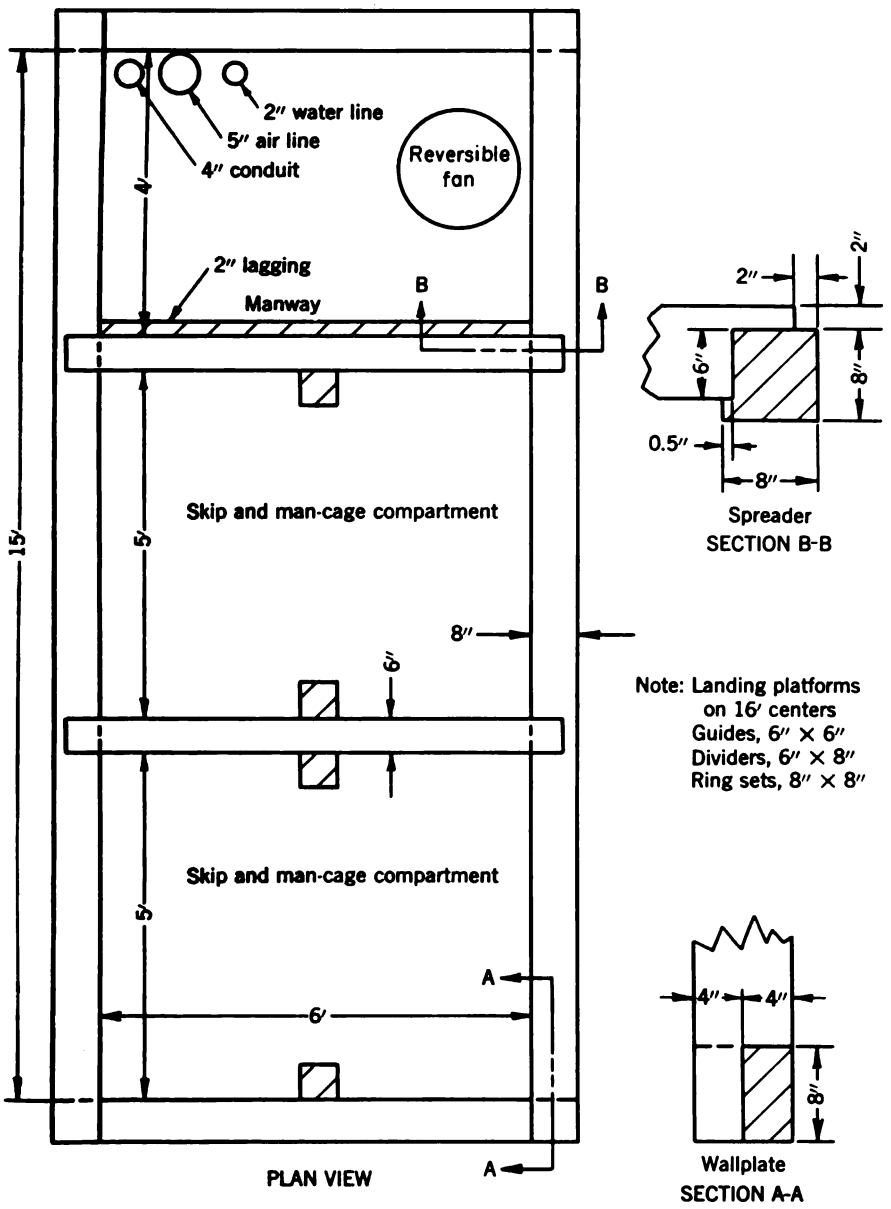

FIGURE 3. - Plan View of Hill-Ledford Three-Compartment Shaft.

of the shaft was lined with concrete poured in 10-foot sections as sinking progressed. When the first 10 feet of shaft was excavated a permanent, reinforced, concrete collar and lining were poured to the bottom of the hole from 1 foot above ground level. The lining operation was repeated for each 10-foot advance until sinking passed through the overburden. After the first 40 feet of the shaft was lined the sinking operations were temporarily suspended on April 11, 1955, while a sinking headframe was constructed over the shaft opening. A 2 1/2-foot single-drum hoist, powered by a 75-hp. electric motor, was installed in the upper part of the headframe, directly over the shaft opening. An installation of this type is frequently used by mining companies in the Tri-State lead and zinc district of Joplin, Mo.

Shaft sinking was resumed in May 1955 and proceeded intermittently to completion in November 1956. During this period an additional 764 feet of shaft was sunk and 70 feet of the shaft was lined with concrete, making a

Generated on 2024-09-22 02:59 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

total of 110 feet of concrete lining. Below this point the shaft was timbered as sinking progressed. At the 724-foot level a 60-foot crosscut was driven to the main ore body, the skip and ore pocket was excavated below the 724-foot level, and the permanent headframe was erected. (See fig. 4). From November 1956 to March 1957 shaft timbering was completed, and loading equipment was installed and tested.

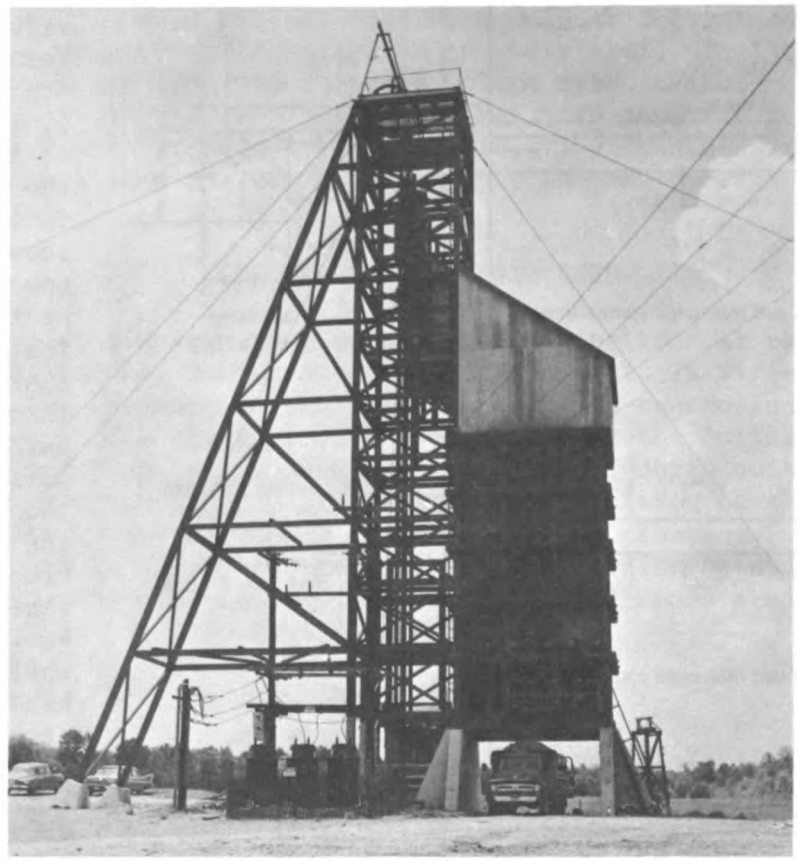

FIGURE 4. - Typical Wooden Headframe.

Sinking operations were conducted on a varying schedule of two or three shifts a day 7 days a week. The working force on each shift comprised three shaftmen, a hoistman, and a part-time foreman. The foreman split his time among all shifts. In the foreman's absence a designated leadman assumed his responsibilities.

Drilling was done with Atlas Copco model BBD-41W percussion rock drills. The drill steel used was 7/8-inch hexagonal Sandvik Coromant hollow drill steel with tungsten carbide chisel bits as an integral part of the steel. Bits were resharpened after drilling 105 feet in the abrasive sandstone and 300 feet in the limestone.

Generated on 2024-09-22 02:46 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The shaft round comprised 40 holes drilled to an average depth of 5-1/2 feet. It required eight V-cut holes, and eight "baby" V-cut holes; the other holes were vertical or nearly vertical. This type of round generally broke 5 feet of solid rock. Three drillers drilled and loaded a shaft round in 3-3/4 hours.

A shaft round was blasted with 7/8- by 8-inch cartridges of 45-percent semigelatin dynamite, using regular delay electric blasting caps. The caps were wired into a series blasting circuit and fired electrically from a 220-volt isolation-type transformer system by the leadman or foreman. The explosive consumption was approximately 30 pounds per foot of sinking progress.

The smoke and fumes produced by the blast were exhausted from the shaft opening in approximately 2 hours by a Joy 7-1/2-hp. Axivane fan which forced fresh air from the surface to the shaft bottom through an 8-inch ventilation tube. The miners were then able to return to the shaft bottom to begin loading broken rock. The blower fan was operated throughout the entire drilling, blasting, and loading cycle.

The blasted rock was loaded into a 29-cu.-ft. sinking bucket by a 1/2-yd. clamshell integrated with an air-operated, single-drum utility hoist. This hoist controlled the movement of the clamshell jaws in picking up or dropping a load. The loading unit moved vertically by a 5/8-inch wire cable attached to the 75-hp. hoist mounted in the headframe.

Four men, three to operate the loading equipment and one hoistman, were required to load the shaft round in approximately 12 hours. Innovations, such as an intercom system to communicate between the hoistman and loader and a snaphook attached to the hoisting cable to facilitate rapid cable transfer from the clamshell to the sinking bucket, contributed to the loading efficiency. With the bucket in loading position, two shaftmen controlled the positioning of the clamshell with ropes while the third man operated the utility hoist. The loaded bucket was hoisted on signal from the shaftmen and emptied by the hoistman into a waste storage bin at the surface. The broken rock was then loaded into trucks and used for fill in the plant area. Approximately 5 percent of the rock was loaded by hand shoveling.

Shaft timbering was begun after the shaft had been sunk approximately 75 feet below the bottom of the concrete lining. A scaffold of steel and wood construction was used in setting timber in the shaft. Bearing sets on approximately 100-foot centers were placed in hitches and wedged. Timbered ring sets were hung on 8-2/3 - or 10-foot centers by hanging bolts and anchored to the walls with wooden wedges. The intervals were shorter when timber lagging was required to retain incompetent, soft-shale wall rock encountered in the shaft at different depths. In the cycle of shaft sinking and timbering a minimum distance of 40 feet was maintained between the last timber set installed and the shaft bottom to prevent damage to the shaft timbers by flying rock. A total of 362 feet of the shaft required lagging.

A 4-inch electrical conduit, a 5-inch air line, and a 2-inch water line were contained in the service compartment. The manway consisted of steel

Generated on 2024-09-22 02:44 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

ladders set on platforms made of 1-1/2-inch expanded metal screens at 16-1/2-foot centers and staggered for safety. The manway compartment was totally enclosed with 2-inch lagging. It was intended to use this compartment as a carrying duct for the controlled circulation of air into the mine, but it developed too many air leaks which could not be effectively sealed. The company now uses a 30-inch duct which is contained in the service compartment of the shaft.

Crosscutting and Drifting

The discovery of an additional isolated ore body on the property of the Oxford No. 11 mine by surface churn drilling necessitated driving a 7- by 7-foot crosscut (see fig. 5) to intersect the ore. A crew consisting of two miners and a hoistman undertook this work one shift a day, 6 days a week. To encourage maximum performance, the two miners were placed on an incentive plan after completing the first 29 feet of crosscut. The hoistman did not participate in this plan. The formation penetrated was predominantly limestone with minor amounts of sandstone.

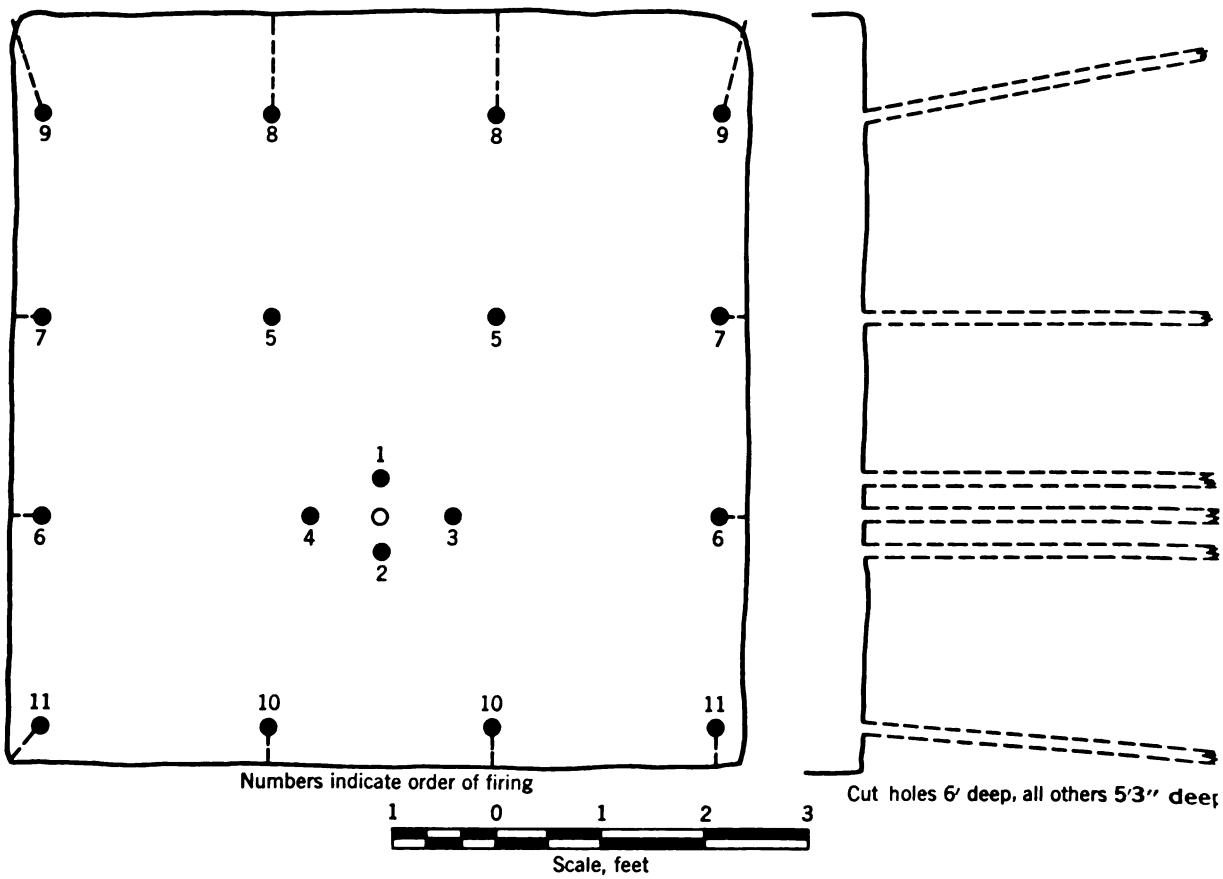

FIGURE 5. - Typical 7- by 7-Foot Crosscut Round.

Generated on 2024-09-22 02:44 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Two Copco Atlas BBD-41WK rock drills, operating on 2-1/4-inch-diameter pneumatic airlegs with a 51-inch feed, were used in crosscutting. The drills were chucked to take 7/8-inch Sandvik Coromant drill steel with a tungsten carbide chisel bit integral with the steel. The crew used 5-foot 3-inch-length steel with a 1-5/16-inch-diameter bit for all drilling.

The two miners worked as a team in preparing the area for drilling. After setting up the drills, the leadman started at the cut while the other miner began in the upper left-hand corner of the face. Teamwork was particularly helpful when collaring holes on a slick face or when properly alining steel to drill the cut holes. One man spotted the steel at the face, while the other slowly applied rotation and feed to the drill. This operation did not noticeably interfere with either miner's drilling performance as it was handled while the other drill was in operation. With a good team of miners each is able to anticipate the moves of the other, and the drills operate continuously.

The blasting round used in the crosscut consisted of 16 to 19 holes drilled to a depth of 5 feet 3 inches. Figure 5 fhows a typical round using a 5-hole burn cut fired in the indicated order. A round broke from 4 to 4-1/2 feet. The two drillers, however, advanced the crosscut at an average rate of about 6 feet a shift.

The holes were cleaned with compressed air released through 3/8-inch pipe connected to an airhose. Blast holes were loaded with Olin-Mathieson 40-percent-strength Mine-Gel dynamite in 7/8-by 8-inch cartridges. The normal charge consumed 75 pounds of explosive per round.

The primers were placed after the first stick to help prevent cutoffs. Care was also taken to load holes properly and to tamp the powder firmly with a wooden pole to within 18 inches of the collar. No stemming was used. The loaded charges were detonated by a No. 6 blasting cap and safety fuse. A 12-inch hot-wire fuse lighter was used to ignite the fuse. One man trimmed the safety fuse for rotation firing while the other watched for errors. Both men participated in lighting the safety fuse after proper safety precautions were taken. They had no definite firing schedule. A blasting round of this type broke about 20 tons of rock. The fragmentation was considered favorable for loading.

The heading was usually cleared of blasting gases within 35 minutes. The crew then returned to the working face. Before loading, the crew scaled down loose or hanging rock and where necessary installed roof bolts.

Blasted rock was picked up by an Eimco air-powered rock shovel, model 12B and dumped into a 2-ton end dumpcar coupled to the loader. When loaded, this car was removed by a storage-battery locomotive and another switched into place. To facilitate the loading cycle, full and empty cars were spotted on a track lay-by in the crosscut. The loaded cars were trammed to the shaft station, placed in the hoisting cage (fig. 6), and on signal from the miner hoisted to the surface. At the surface the waste rock was dumped by an automatic dumping unit into a bin. Loading, tramming, hoisting, and cleaning a

Generated on 2024-09-22 02:48 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

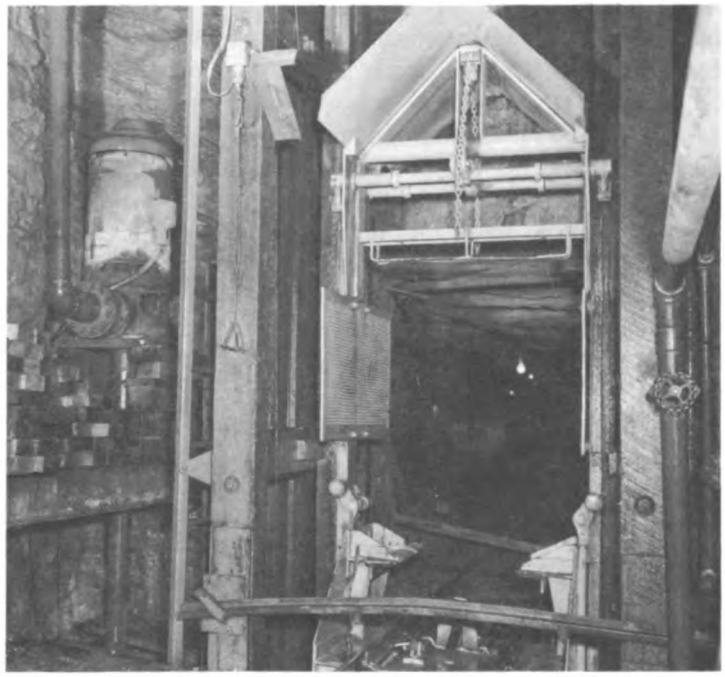

FIGURE 6. - Typical Mine-Car Hoisting Cage.

round of blasted rock by hand shovel generally took from 1-1/4 to 1-1/2 hours. Ten to twelve 2-ton cars were loaded intermittently at a loading speed of 20 to 35 c.f.m.

The shaft was upcast when the crosscut was driven, and undesirable gases and dust were removed rapidly by circulating air forced down a 6-1/2-inch drill hole (drilled during exploration) by a Buffalo 5-hp. electric fan set over the hole which cut the crosscut approximately 95 feet from the shaft.

On the main mining levels at the North Green and Hill-Ledford mines, mining and haulage drifts normally are driven a minimum of 10 by 14 feet in cross section. This size provides working clearances for operating large loading, carrying, and dumping equipment. Development techniques roughly parallel present mining techniques. An explanation of the mining system is given under stoping.

STOPING METHODS

The selection of a stoping method is based on the shape of the ore body and the ability of ore and surrounding waste rock to withstand the forces imposed on them during mining. The open-stope method with pillar support has been adopted by the Ozark-Mahoning Co. at the North Green mine and at similar mines operated by them in the Cave-in-Rock fluorspar area, because the ore is deposited in flat-lying beds and the rock in the roof is easily supported. The description of the stoping method at the North Green and Hill-ledford mines is presented to illustrate this open-stope practice.

The North Green mine opening is a vertical shaft that connects levels comprising haulageways, stopes, and loading stations. The stopes are turned off the main haulageways on a grade to conform with the dip of the ore beds and to facilitate haulage and drainage. (See fig. 2, p. 5.)

The stopes are driven into the ore body at their full height and width on advance or are formed by enlarging narrow drifts which at times may precede the stoping operation. Stopes are connected at random intervals, leaving pillars of different diameters at various distances. The grade of ore mined is maintained constant by selective mining practices.

Generated on 2024-09-22 02:44 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Drilling and Blasting

For regular stoping at all of the company's flat-bedded deposits, blast holes are drilled with Atlas Copco model BBD-41W or Cleveland model H-10 wet-type percussion drills used as drifters in combination with light airlegs (See fig. 7.) The airleg consists essentially of a cylinder housing, a piston rod, and a piston actuated by compressed air. The function of the airleg is to keep the feed pressure on the drill at all times. The pressure can be adjusted as required by a reducing valve. When used without the airlegs, the drills perform as sinkers in such work as shaft sinking and benching and as jackhammers for secondary blasting. The model BBD-41W has a 2-15/16-inch piston diameter with a 1-3/4-inch stroke that delivers as much as 3,500 strokes per minute at a rated air consumption of 110 c.f.m. at 95 p.s.i. pressure. Drill steel is 7/8-inch hexagonal carbon steel with an integral tungsten carbide chisel bit.

FIGURE 7. - Typical Airleg Drill in Operation.

The use of a drill of this type with an airleg permits simple and rapid setups on irregular bottoms. Rapid setups increase the drill operating time per shift and allow easier cross-sectional coverage of the working face than the heavy column-mounted drifters previously used. Thus, a greater tonnage is blasted per drilling shift. Because the drill is relatively light weight and handles easily, drilling has become a one-man operation. This combination has increased the efficiency of the drilling cycle and thus reduced operating costs. Comparative tests between tractor-mounted Jumbos and airleg drills indicated that the airleg drills were less costly to operate.

The "swing" or V-cut stope round is used when working a full production face. The swing round is illustrated in figure 8. The blast holes for a swing stope round are drilled 5 to 7-1/2 feet deep and spaced about 2-1/2 feet apart over an area approximately 10 by 14 feet in cross section. However, the

Generated on 2024-09-22 02:46 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

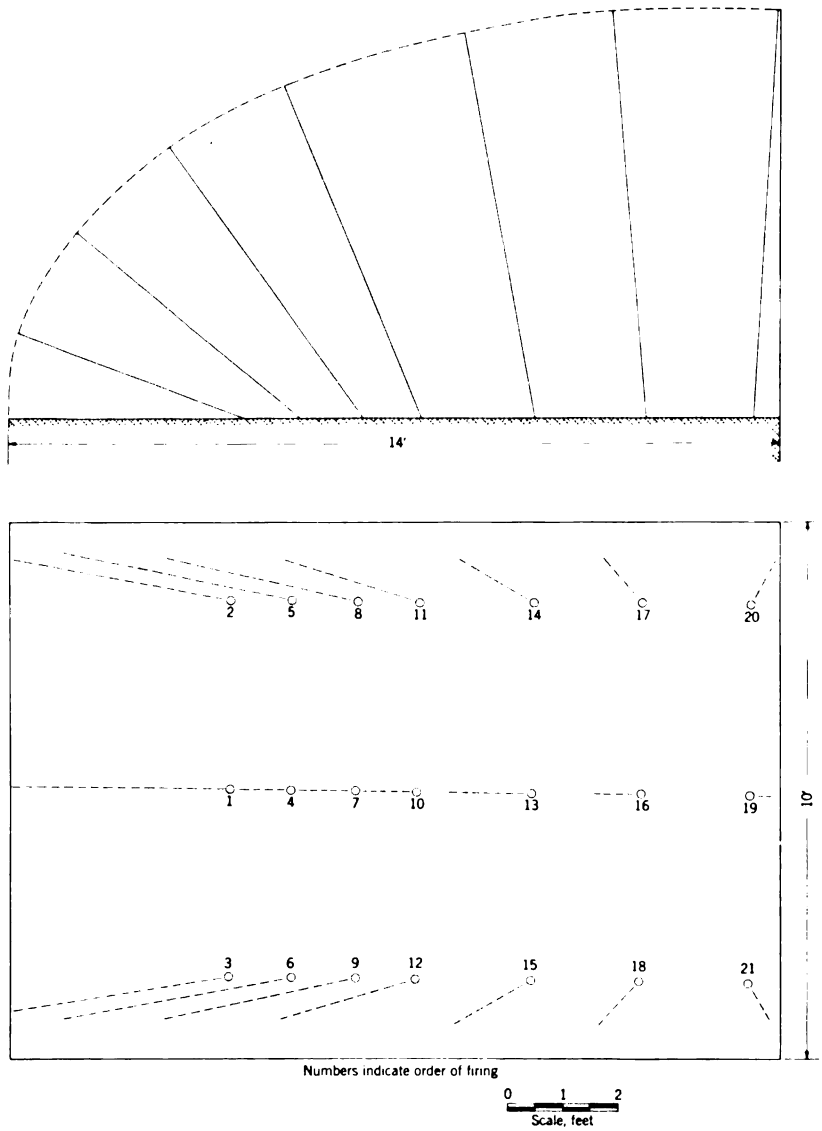

FIGURE 8. - Typical Stope Blasting Round.

number, spacing, and depth of blast holes usually are left to the judgment of the miner. In the swing round, the first vertical row consists of short blast holes drilled to start a break in the face. These short holes are followed by rows of holes drilled in a pattern assimilating a quarter circle. This type of round minimizes scattering of blasted rock and exposes two free faces for more efficient blasting. The wall with two free faces is then drilled with parallel slabbing holes until the room reaches the desired width. A 6-hole V-cut blast round is also used extensively to break ore at production faces. A pair of V-cut holes are spaced 3 feet apart at the hole collars and about 1 foot apart at their bottom. The subsequent relief holes are spaced approximately 2-1/2 feet between hole collars. Successive cuts by either type of round advance the stopes in any direction with intervening ore being cut through at intervals to form pillars. Stopes are advanced along the trend of the ore to its extremities. The holes are cleaned with compressed air released through 3/8-inch pipe connected to an airhose. Blast holes are loaded with Olin-Mathieson 40-percent-strength Mine-Gel dynamite (7/8- by 8-inch or 3/4- by 8-inch cartridges) at a ratio of one stick per foot of depth. An average of 1.2 pounds of dynamite is used to break a ton of ore. The primer, consisting of a dynamite cartridge, a standard blasting cap, and a safety fuse, generally follows the first cartridge placed in the hole. At the end of the shift the driller ignites the charge with a hot-wire fuse lighter. The rock is blasted to a size that requires a minimum of secondary blasting and is easy to load.

Generated on 2024-09-22 02:46 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The integral drill steel and chisel bits are brought to the surface when dull. They are picked up periodically and resharpened in a modern, centrally located surface shop equipped to service all the company's mines in the Cave-in-Rock area. The drill-steel grinder has simple adjustments for different edge angles and edge radii. This grinder is also provided with a built-in cooling water system. Bits are resharpened after drilling about 105 feet in sandstone and 300 feet in limestone. Special care is taken to avoid using bits after they have become dull. A blunted bit and the loss of gage produces undue stresses in the drill steel and the rock drill. When a loss of gage occurs, the drill steel is discarded or the bit ends are formed to take detachable bits for use in drilling pinholes to anchor sheave blocks used during slushing. When the drill steel fails between the bit end and the shank collar the steel is returned to the supplier who has it pressure-butt-welded, if the bit life left warrants welding or if the steel should not be reshanked. This practice has proved reasonably satisfactory. When the drill steel fails just below the shank, it is reshanked at the mine shop.

Methods of Ground Support

Rock pillars are the simplest way of supporting ground, provided that each pillar is capable of withstanding the ground pressure to which it is subjected. The pillar size and spacing are determined by the strength of the pillar and the span of roof rock that will stand unsupported. At the North Green and Hill-Ledford mines 15- to 20-foot-diameter pillars have been left on 40- to 60-foot centers and staggered so as to form triangles with pillars at their corners. These pillars represent about 25 percent of the minable ore. The staggered pattern places definite limitations on the length of the open spans and controls lines of weaknesses. Formerly, supplemental ground support by timbers was used when pillars would not support the overlying rock and at local points when the roof structure was weak between pillars. Early mining methods and equipment necessitated the use of timber, but modern methods and machinery virtually eliminate the need for such support. At present roof bolting has become the accepted method of supplementing pillar support; it provides clearance for the large mobile mechanized loading and transporting equipment and does not obstruct ventilation. Roof bolts are used also in combination with channel iron, as shown in figure 9. However, the combination method is not representative of the general practice.

Roof bolts are used in 5- and 7-foot lengths, with 3-foot extensions. The bolt is a standard 3/4-inch rod that is threaded on one end and has an integral head nut at the other end. The 3-foot extension rods are designed so that any number can be coupled to the standard roof bolt. One end of the extension rod is 3/4-inch threaded female coupling and the other end a 3/4-inch threaded male coupling. The extension rods have proved beneficial where it was necessary to use them.

The anchoring device is a bail-type expansion shell which does not require a means of keeping the shell from sliding along the bolt during installation. In addition, a 6- by 6- by 1/4-inch plate (washer) is used to eliminate drawing the nut into the hole and to give a greater bearing surface.

Generated on 2024-09-22 02:58 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

FIGURE 9. - Method of Roof Bolting Relatively Thin Layers of Roof Rock.

Numerous 3- by 3- by 3/32-inch convex tension-indicator plates, with 1-3/8-inch diameter center holes, are being tested to determine the advantages of using such plates. A unit consists of the tension indicator, a special 6- by 6- by 1/4-inch bearing plate with a 1-3/8-inch-diameter center hole, a 1-3/8-inch bushing, and a special nut. When the proper bolt tension is applied, the plates flatten, indicating that the bolt has been properly seated. However, when excessive stress is placed on the bolt, the indicator becomes concave and forms against the bearing plate.

Holes to accomodate bolt assemblies of any length are drilled on approximately 4-foot centers with a stoper drill using a bit to make a 1-3/8-inch-diameter hole. The bolts are tightened with either a pneumatic wrench that is geared to slip when the proper tension is applied or a modified stoper. The direction of rotation of the stoper mechanism was reversed so that it could be used to tighten bolts (see fig. 10). A torque wrench is used occasionally to spot check anchorage immediately after the bolt is secured and periodically thereafter to check the continued effectiveness of the bolts.

Loading

Loading at the North Green and the Hill-Ledford mines is done with self-propelled scraper loaders or crawler mounted, overhead-discharge loaders. (See figs. 11, 12, and 13.)

Generated on 2024-09-22 02:55 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

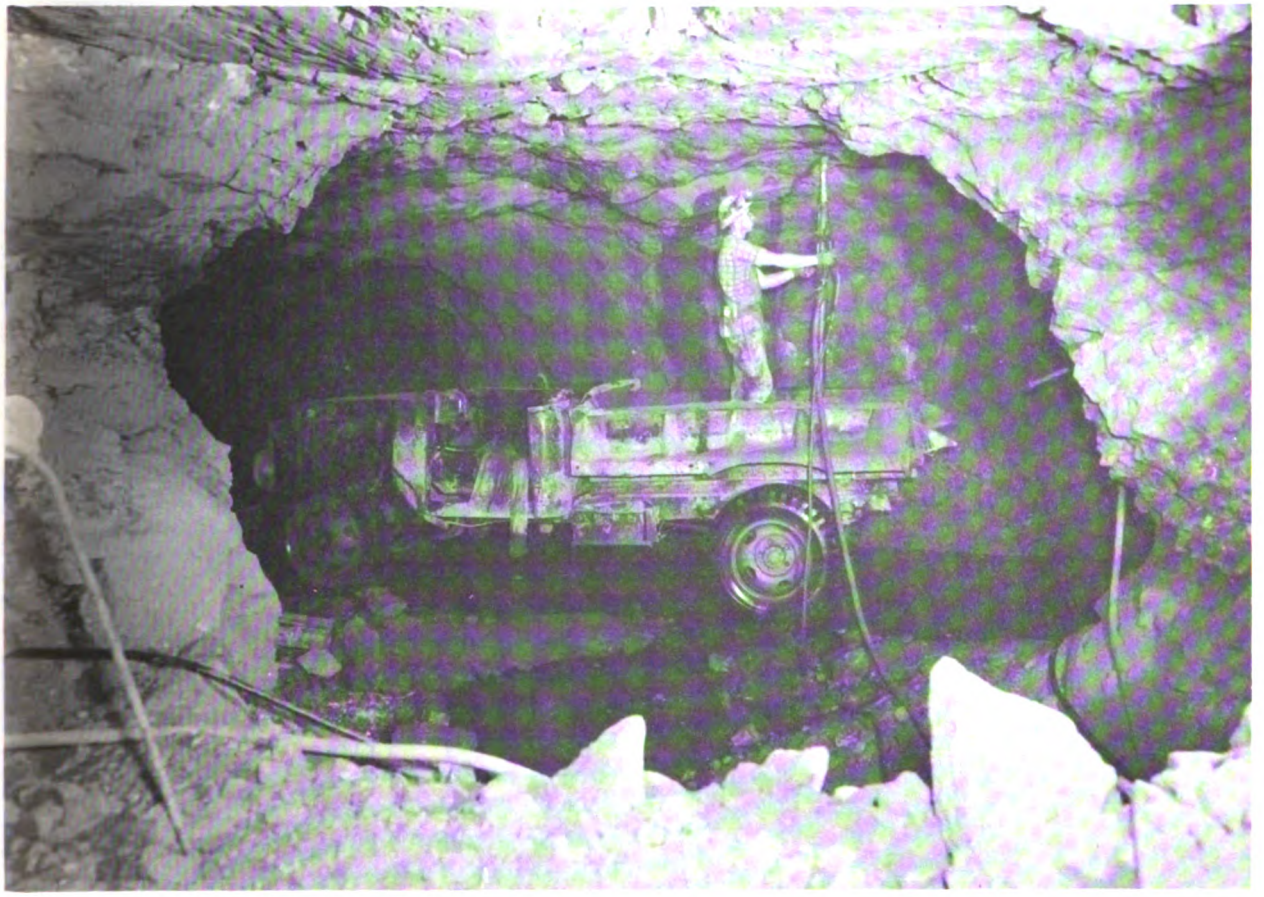

FIGURE 10. - Using a Truck Bed as a Platform to Bolt a High Back.

The scraper unit consists of a three-drum hoist powered by a 20-hp. electric motor, three wire ropes of suitable lengths, a loading ramp with a slotted opening, a 42-inch scraper, and either a crawler-mounted base (electrical or air-driven) or a truck chassis driven by electric motors. In addition, sheave blocks (wide-throat), wedges, and eyebolts are provided with each unit. Viewed in cross section the unit shows a slusher hoist mounted over the front or loading end of the ramp, which in turn is mounted on the ramp chassis. The slotted opening at the upper end of the ramp extends over the unit to be loaded.

The loader is prepared for operation by pinning the tail-rope sheave blocks on the advancing face with eye and wedge-type bolts at a spacing to give as wide a scraper coverage of the broken ore as possible. From the slusher's pull-rope drum, the rope is spooled through a block located above the opening in the ramp, passed by the idler rollers at the mouth of the ramp, and attached to the scraper.

The scraper rakes the broken rock from the working face to an opening in the bed of the ramp, through which it passes into the trucks. Under normal loading conditions, a scraper unit will load 5-1/2 tons in 3 minutes.

Generated on 2024-09-22 02:49 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

FIGURE 11. - Typical Crawler-Mounted Slusher Ramp.

FIGURE 12. - Typical Pneumatic-Tire-Mounted Slusher Ramp.

The scraper loader is favored because the grade and regularity of the floor has only a small effect on its loading efficiency. It can load large fragments of rock, requires only a normal amount of maintenance, and cleans the bottom well. Its long reach makes it a highly versatile loading rig, particularly when scraping from places with low headroom or when working on pillar extraction. Under these conditions, the unit can remain stationary as much as 100 feet from the blasted rock in an area of adequate headroom and protection. Safety of operation is increased by this practice. As the scraper requires a minimum clearance of 2 feet, mining 4-foot thicknesses of ore at the boundaries of an ore body becomes economically feasible. The major disadvantages of the scraper loader are the expenditure of 1-1/2 hours for rigging before loading can begin and the lack of thorough cleaning in the area at the lip of loading unit. The unit also requires more headroom than other loading equipment used at these mines. The crawler-mounted overhead loader used at the Hill-Ledford and North Green mines has the advantage of high mobility, loading as soon as it reaches the loading area, and requiring only normal maintenance. The principal disadvantage is that it will not dig with headroom less than 6 feet and will not load in heights less than 9 feet.

Generated on 2024-09-22 02:51 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

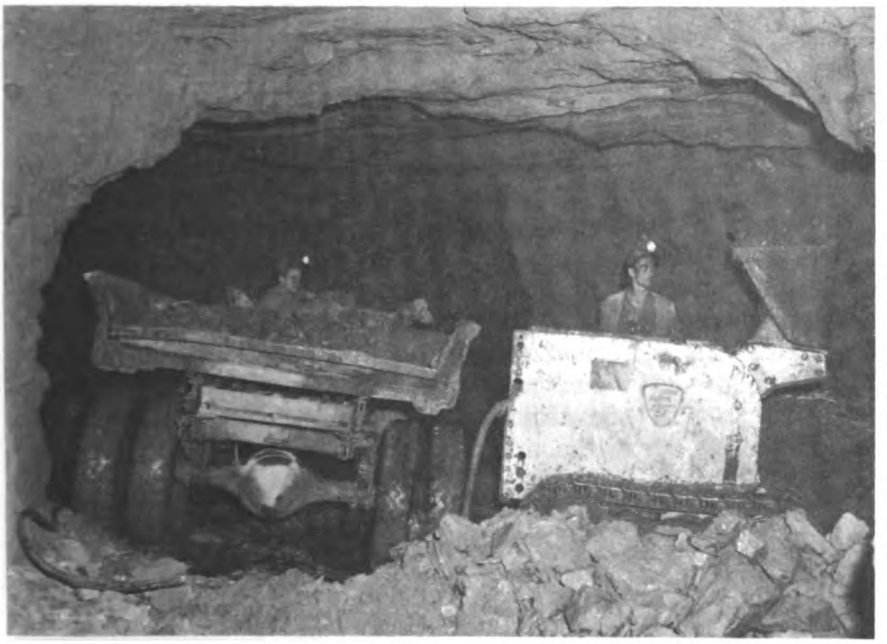

FIGURE 13. - Trackless Overhead Leader in Operation.

UNDERGROUND TRANSPORTATION

The problems of underground transportation are many. Haulage units of adequate number and capacity to efficiently utilize the loading equipment must be used. In selecting equipment that will haul the ore efficiently and economically, other factors such as the shape, horizontal area, volume, regularity of the boundaries, thickness, dip, and continuity of the ore also must be considered.

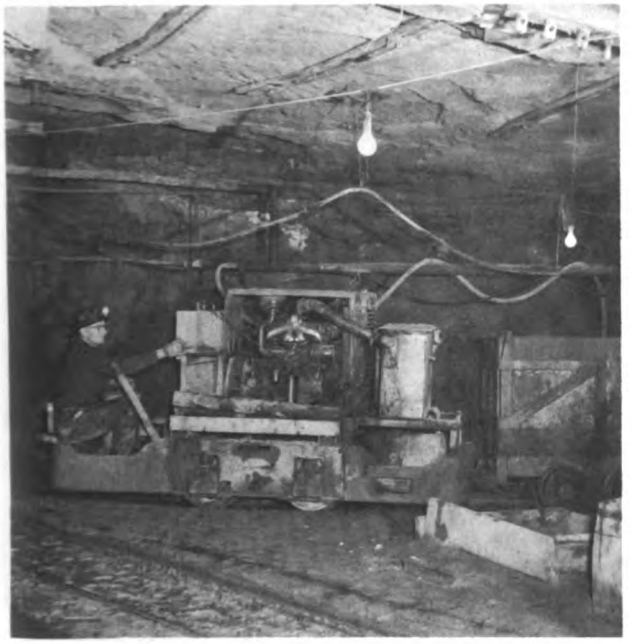

FIGURE 14. - Diesel Locomotive Used in a Truck Haulage System.

The company uses either rail (see fig. 14) or trackless haulage equipment in their active mines. Each mine uses the mode of transportation best suited to its type of operation, although the current trend is to use diesel trucks wherever possible. Illinois allows diesel-powered equipment in underground operations only under special permit. The haulage system under discussion represents practices at the North Green and Hill-Ledford mines.

The North Green mine uses a combination truck, ore-storage pocket, conveyor belt, and skip to transport ore from the production area to the surface. Currently, two types of trucks are used - one semitrailer unit and two 2-ton trucks.

The semitrailer features a wide, open-mouthed body with a low loading height which makes an easy target for any overhead loading devices. It

Generated on 2024-09-22 02:49 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

also features a high-strength-steel body with a drop bottom and a payload capacity of 7 to 8 tons. This trailer is pulled by a 48-hp. diesel-powered crawler tractor. The 2-ton trucks have identical 2-1/2-yard end-dump beds. However, one truck has a swivel frame and the other a conventional solid frame. The swivel frame consists of a main frame member of a truck designed to swivel at approximately midpoint when subjected to a torque stress on either the fromt or back wheels. Each unit is powered by a 65-hp., 4-1/2- by 4-1/2-inch (bore and stroke) diesel engine. The company designed its own truck bed which is flared and reinforced with angle-iron lining. The swivel-frame truck was purchased partly to reduce frame twisting and subsequent failures caused by travel over ungraded mine floors. The company plans to convert all standard trucks to units with swivel frames because of the successful application of this type of unit at the North Green and Hill-Ledford mines. (See fig. 15.) All trucks are provided with exhaust scrubbers to eliminate as much carbon deposit as possible and to remove the bulk of the aldehydes produced.

FIGURE 15. - Typical Haulage Truck Used Underground.

Once the trucks are loaded, they haul the ore to the shaft station where it is dumped onto a grizzly constructed of 3-inch steel bars spaced on 11-inch centers. The minus-8-inch ore passes into a 50-ton-capacity tapered hopper. The oversize material is sledged through by a grizzly attendant. A 48- by 96-inch Rogers Rok-ore panfeeder at the bottom of the hopper passes the ore from the hopper to a 30-inch conveyor belt. The belt carries the ore to the shaft and loads the skip, which hoists the ore to the surface where it is dumped into a storage bin. The ore is then loaded into trucks and delivered to the company mill at Rosiclare, Ill.

Generated on 2024-09-22 02:49 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

At the skip-loading level, a skip tender controls the loading cycle with a unit control that places the panfeeder and belt in operation at the same time to avoid overloading the belt's power unit. A drop chute, hinged to the superstructure of the conveyor belt and controlled by counterweights, is used to bridge the span between the belt and the skip.

Belt failure is occasionally caused by "chunking," which occurs when large pieces of rock with sharp edges are dropped onto the belt from the panfeeder. These chunks make small cuts in the belt and shorten its life. To lessen such abuse, impact idlers and splash plates have been installed at the belt-loading point. These installations have extended the normal life of the belt, which has been determined to be approximately 6 months.

The skip tender is responsible for minor belt repairs and adjustments. He adjusts the belt tension and alinement with takeups mounted on each side of the receving end of the belt to reduce belt wear.

Performance records show that this system is capable of delivering an average of twenty-six, 2-3/4-ton skip loads an hour under normal operating conditions.

At the Hill-Ledford mine, trucks transport the ore from the working face to a primary crushing and skip-loading unit adjacent to the shaft. The ore is dumped on a 10- by 12-foot grizzly that allows material less than 18 by 30 inches to pass through its openings. (See fig. 16.) Oversize material is sledged through. The ore is then handled consecutively by a steel-lined hopper, panfeeder, jaw crusher, crushed-ore pocket, measuring pocket, and skips. The ore is hoisted and dumped into the hopper or surface bin. (See fig. 17.) The grizzly is constructed of 4-inch-diameter steel rods. It is set in a concrete collar over a 255-cu. ft. steel-lined hopper with beveled sides. A 36-inch by 10-foot chain-driven panfeeder at the base of the hopper transfers the crude ore to a Diamond 24- by 36-inch jaw crusher. The feeder also acts as a gate to hold the ore in the tapered hopper when the crusher is not in operation. The crusher, powered by a 75-hp. electric motor, is capable of handling approximately 150 tons per hour with a 4-inch jaw setting. The crushed ore drops into a 150-ton crushed-ore pocket. Measuring pockets equipped with air-operated guillotine gates are located in the lower section of the steel-lined crushed-ore pocket. These pockets hold 2-1/4 tons of ore that will be dumped into the skips.

AUXILIARY OPERATIONS

All underground shops are in mined-out rooms centrally located in the mines. Therefore, no special ventilation other than the regular mine system is used. Approximately 50 percent of the repairs to underground trucks and loading units are performed here and 50 percent at or near production faces. One man lubricates all operating equipment weekly.

Generated on 2024-09-22 02:50 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Compressor Plant

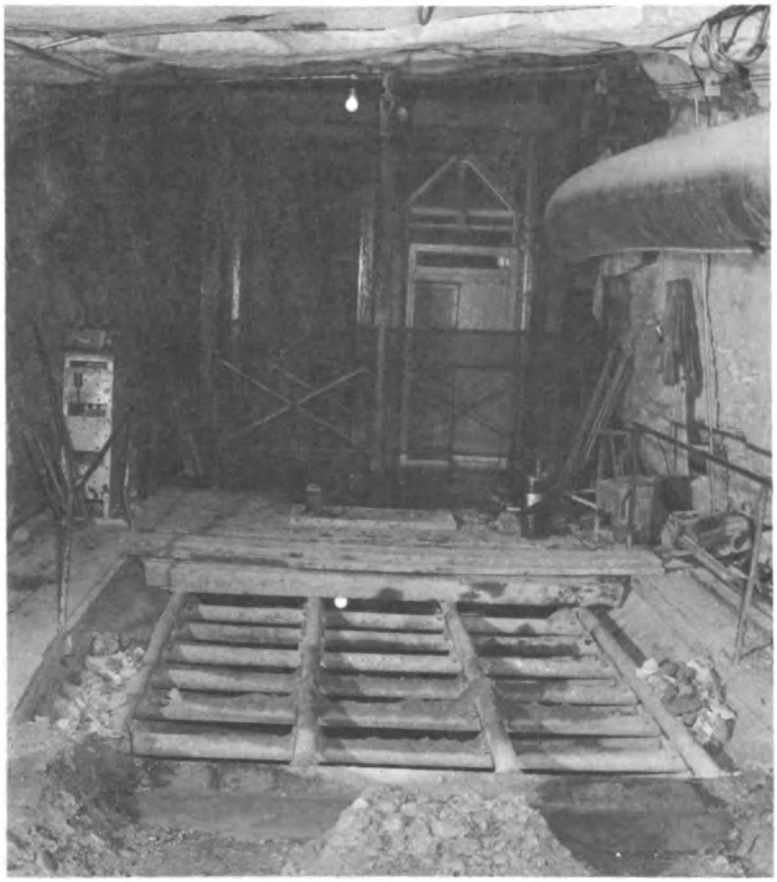

FIGURE 16. - Hill-Ledford Grizzly at Mining Level.

The compressed air equipment at the Hill-Ledford mine consists of two compressors feeding a single air receiver. The compressors have a combined air capacity of 1,400 c.f.m.; one is rated at 600 c.f.m. and the other at 800 c.f.m. They compress the air to gage pressures ranging from 90 to 100 p.s.i. The water for cooling the compressors is pumped from the mine water supple tank and returned to the tank over louvers. The compressed air is transmitted underground through a 5-inch steel pipe located in the service compartment of the shaft. The company has recently installed a compressor plant which includes a water softener (see fig. 18) at the Parkenson mine, located outside the Cave-in-Rock area. This accessory has eliminated the practice of cleaning limewater scale out of the compressor unit at 6-month intervals, as is generally required with units now in operation in the fluorspar district. The compressor shown in figure 18 can be placed on skids for semipermanent installations.

Ore Handling on the Surface

The Ozark-Mahoning Co. operates several mines within an 18-mile radius of its milling facilities. The company has contracted with local firms to transfer the ore from its surface ore-storage bins to the mill at Rosiclare, Ill., or to the mine or mill stockpile. The cost, including loading, hauling, and dumping the ore, is 95 cents a ton. Standard trucks with a load capacity of 7-1/2 tons and tandem trucks with a capacity of 14 tons are used to transfer the ore. These trucks dump their loads into one of four 150-ton storage bins at the mill, according to the type of ore mined.

Generated on 2024-09-22 02:50 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

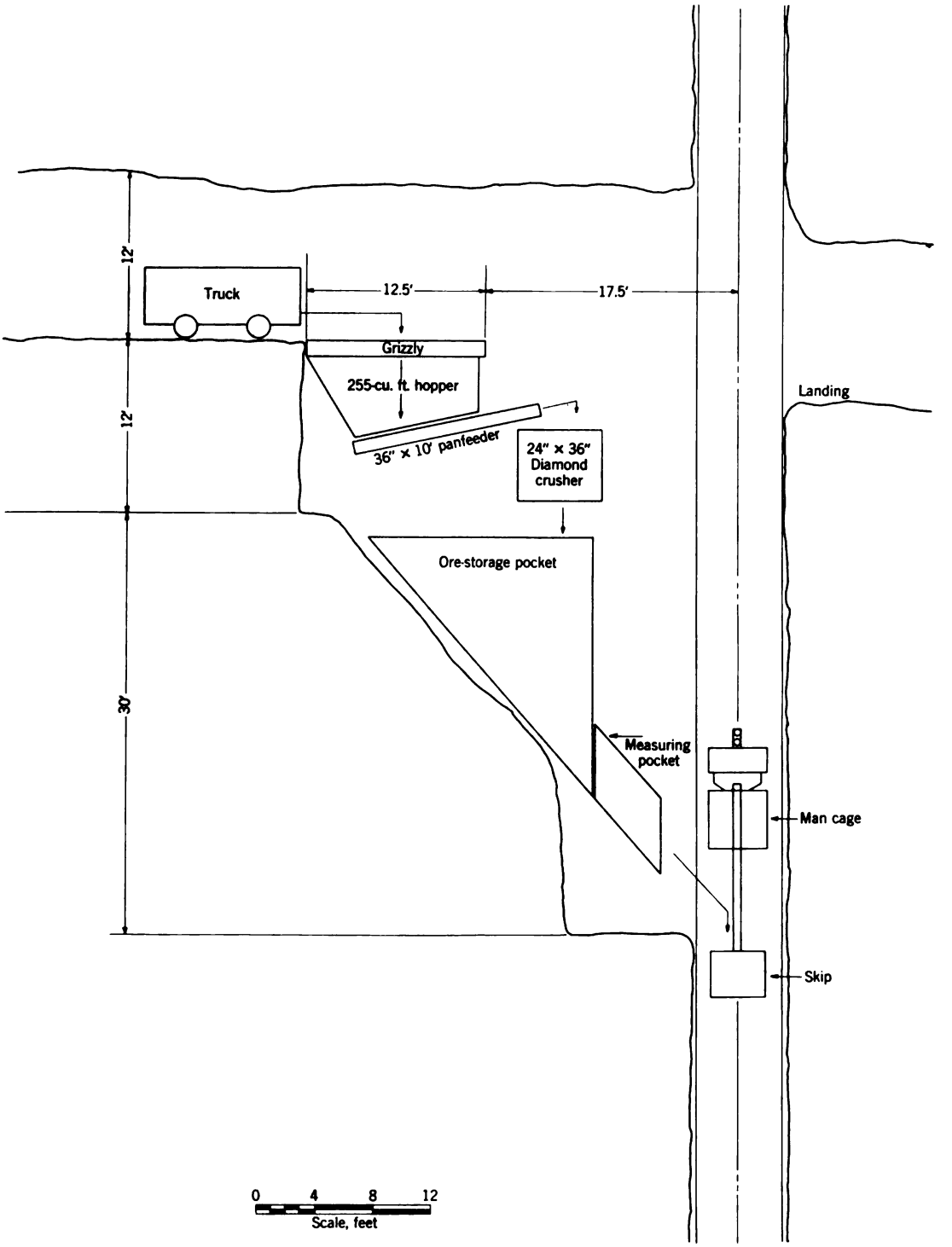

FIGURE 17. - Primary Crushing and Loading Unit at Hill-Ledford Mine.

Generated on 2024-09-22 02:45 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

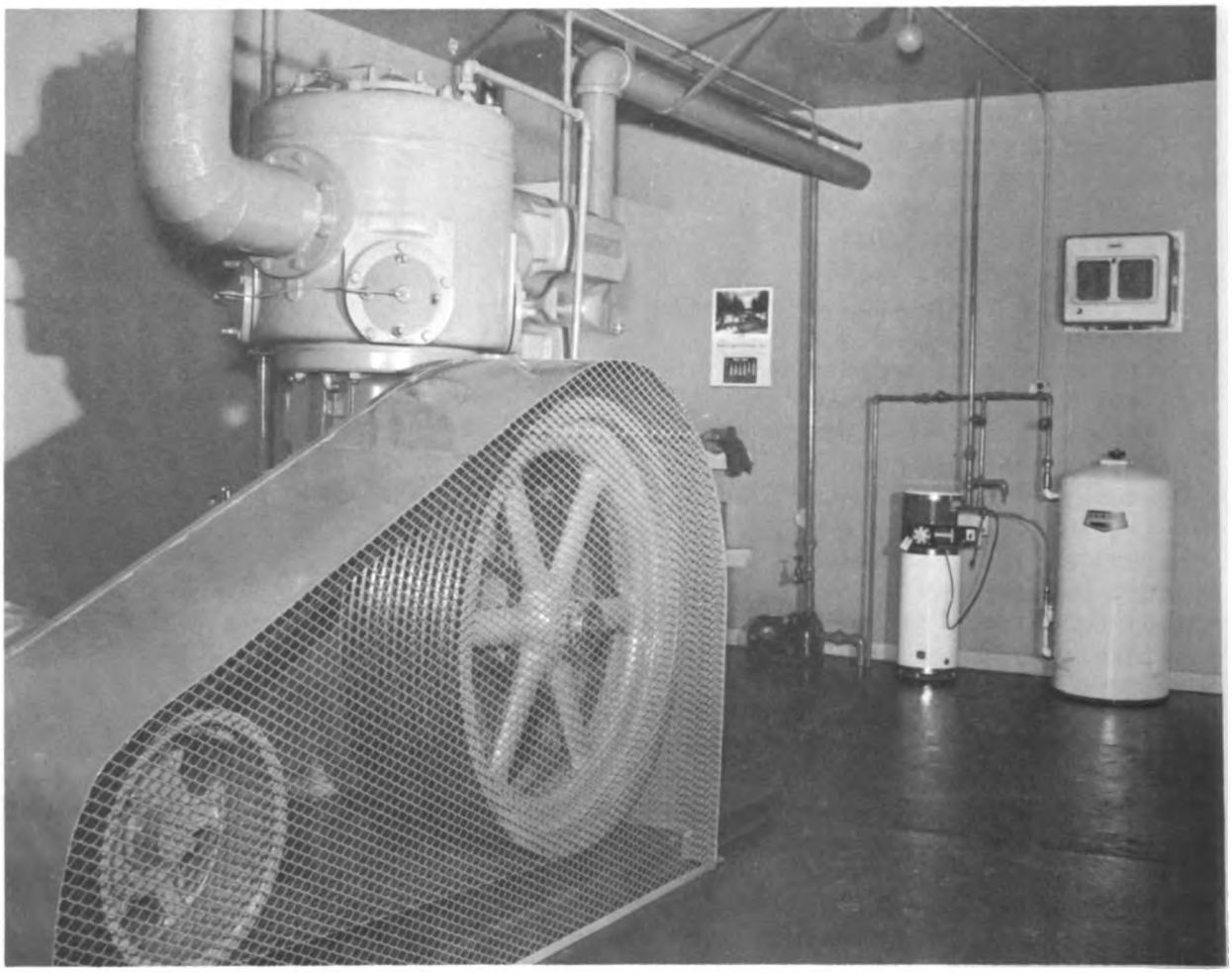

FIGURE 18. - Compressor-Plant Installation Which Includes a Water Softener.

The ore is stockpiled when the mill is down for repair, when there is scheduled mine overproduction to obtain good mining costs, or when the ore is too wet for the mill to process. An area close to the mill has been reserved for stockpiling so that the cost of transfer from the pile to the mill would be small. The proximity of the stockpile ore permits the mill operators to blend it with other incoming ores to regulate the mill feed.

Surface Facilities

The company has erected two buildings and a permanent headframe with a 150-ton storage bin at the Hill-Ledford shaft. One building contains the hoist, compressors, repair shop, and office. The other is a change room with shower facilities. A wooden headframe 93 feet high was erected over the

Generated on 2024-09-22 02:44 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

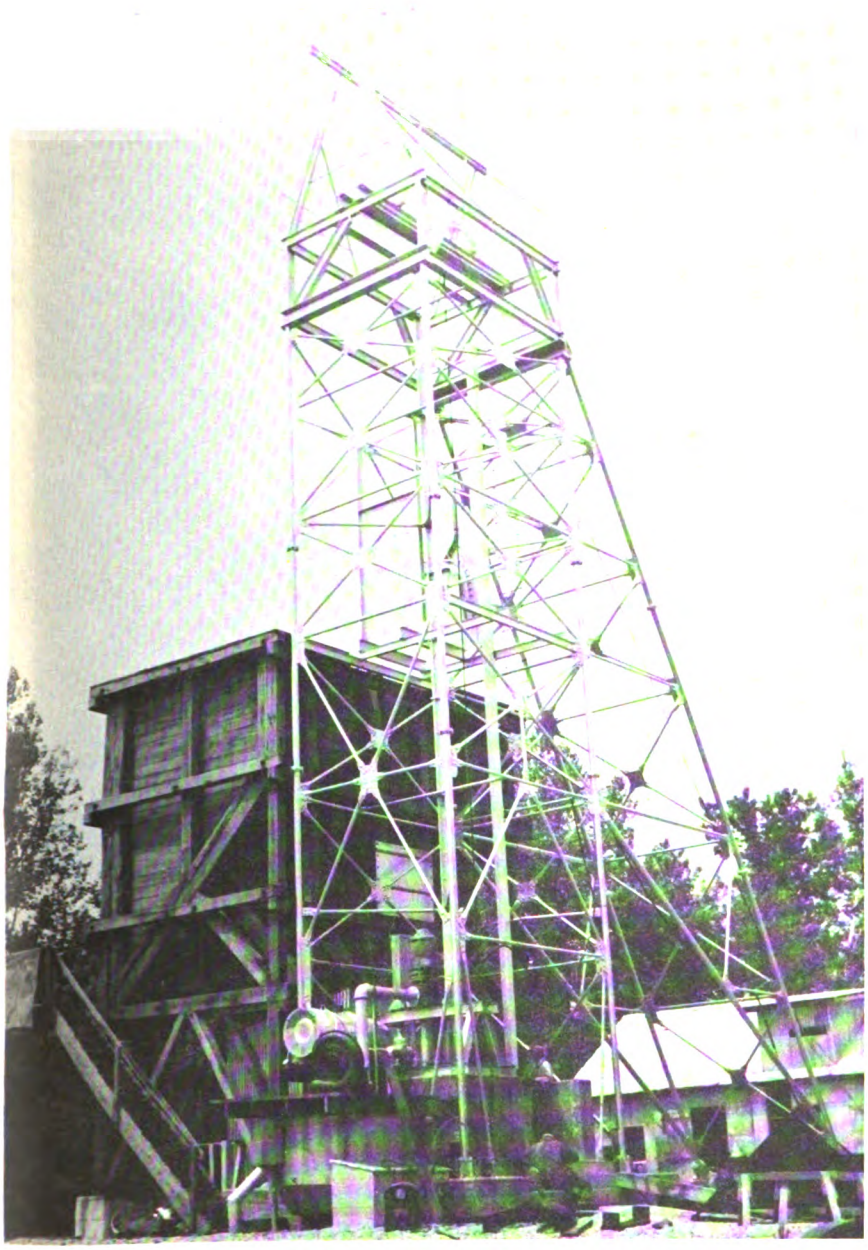

FIGURE 19. - Headframe Constructed of 4-Inch, API Rotary-Drill Pipe.

three-compartment shaft. Figure 19 shows recent headframe installation at the Parkenson mine.

The Hill-Ledford hoist is a single-drum herringbone-gear-drive type. The drum is 5 feet in diameter, 6 feet long, and helically grooved to accommodate 1,000 feet of 1-inch 6 by 19 regular-lay wire rope. The hoist is powered by a 150-hp. slipring induction motor and a reduction gear that will wind the hoist rope at a maximum speed of 800 f.p.m. (See fig. 20.) The hoist is equipped with a Lily controller, which prevents overspeed and overtravel. A bell warns the operator when the skip nears the surface. The controller sets the brake in the event of a power failure.

POWER

The Rural Electrification Administration delivers electric power to a bank of three 100-k.v.a. transformers located adjacent to the Hill-Ledford headframe. The incoming 12,000 volts is reduced to 440 volts. A 1-million c.m. (circular mil) neoprene-covered feeder cable extends from the 440-volt terminals of the transformers to a 2- by 3-foot primary junction box attached to the headframe. This and other junction boxes used at the mine are equipped with separate plug-in connectors and fuse-type circuit breakers. From the primary box the 440-volt power is transmitted into the mine through a rubber-covered 600,000 c.m. feeder cable contained in a 4-inch galvanized-steel conduit. The conduit is hung in the service compartment of the shaft. The cable is connected to a 3- by 3-foot junction box

Generated on 2024-09-22 02:45 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

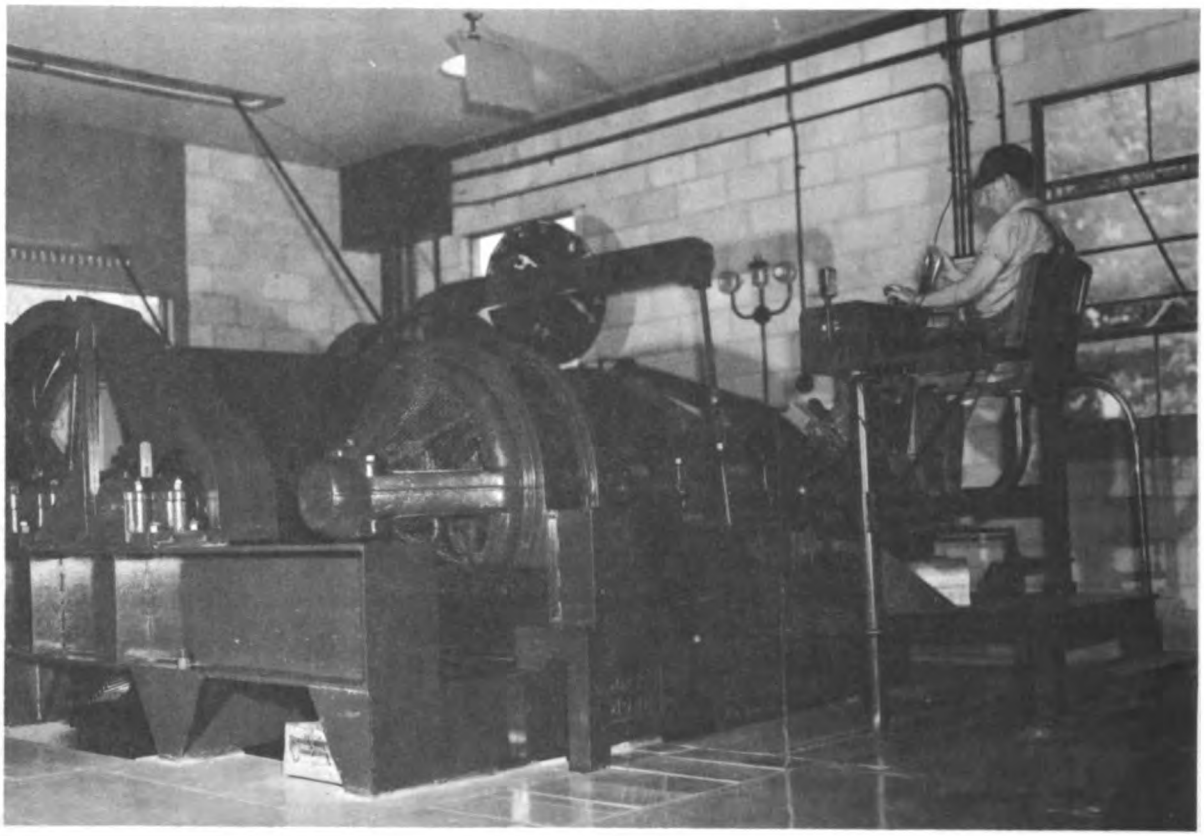

FIGURE 20. - Hoisting Facilities at Hill-Ledford Mine.

on the mining level. Power (440 volts) is distributed to the crusher, pan-feeder, and slushing-equipment motors from the mining-level junction box. The voltage is further reduced underground to 110 by a single-phase transformer, which supplies power to operate lights, sump pumps, and service equipment. In transmitting the lower voltages to operate the hoist signal and limit control switches, telephones, mine-lighting system and welding machines, No. 12 rubber-covered wire is used. Power to operate the hoist and compressor-drive motors is obtained from the 440-volt surface transformers. A standby diesel-powered generator is available in case of power failure.

Power to operate low-voltage surface equipment and lights is obtained from a 440- to 220- or 110-volt transformer.

PERCENTAGE EXTRACTION AND PRODUCTION RATES

Approximately 75 percent of all minable ore in an ore body is extracted in the first stage of mining. The remaining 25 percent is left as pillars. The percentage extraction is increased when the pillars are either reduced in size or totally removed in the second stage of mining during which 80 to 90 percent of the ore in the pillars is recovered. The actual percentages removed depends on conditions encountered in both stages of mining. The use

Generated on 2024-09-22 02:50 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

of roof bolts, the continuity of the ore, the pillar arrangement, the determined value of the pillars, and the strength of the roof are the most important factors controlling the percentage of extraction.

When a 6-foot thicknesses of ore is encountered while driving haulage drifts to provide clearance for large mobile equipment, mining is done in two stages. Breast-stoping methods are used to blast, scrape, and load the blasted ore with a mining height to correspond to the ore thickness. In the second stage an additional thickness of 3 feet of waste rock is mined. This material is transported to the surface for disposal to the waste dump.

Daily production at the Hill-Ledford and North Green mines ranges from 15 to 27 tons per man-shift.

MINING METHODS IN CAVE-IN-ROCK AREA

The method of stoping at the North Green mine is similar to that used at other operating mines in the district. All these mines use naturally supported open stopes. Such practices as development, loading, hauling, and crushing the ore vary at each mine.

Access to the ore is by either adit or shaft, depending on the relative location of the ore to the surface. Although the size of entry varies at each mine, it is the size and type of vehicle used in the materials-handling system that determines its size.

The operating mines in the Cave-in-Rock fluorspar area use various equipment to load the ore - either front dump or overhead shovel loaders and/or portable or stationary slusher ramps. The ore is loaded into trucks, mine cars, or cans. The trucks transport their loads to the surface through an adit or to shaft stations where the loads are dumped into a grizzly chamber for subsequent hoisting to the surface. Some mines have installed a crushing unit between the grizzly chamber and the skip-loading ore pocket. One mine operated a conveyor-belt system that transported ore two-thirds of the distance from the working face to the shaft ore pocket but abandoned the system as too costly. In some mines the ore is loaded into steel buckets (cans) carried by mine-car flat-bed trucks (dollies). The buckets are trammed to the shaft station by either a battery- or diesel-powered locomotive. The loaded cans are hoisted to the surface, emptied, and returned to the mine.

VENTILATION

The North Green mine workings are ventilated by both natural and mechanical methods. Natural ventilation is used between the North Green shaft and the shaft of the adjacent East Green mine. The two mines are connected by a crosscut and interconnected stopes. (See fig. 2, p. 5.) The fresh air generally enters the mine through the North Green shaft, flows through the main haulageways, and exhausts through the East Green shaft. To control the flow of air through the mine, a combination pressure-exhaust fan has been mounted over the manway compartment at the East Green mine. The fan is used to exhaust air from the mine, thus the North Green shaft is downcast. In cold

Generated on 2024-09-22 02:53 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

weather, however, the air flow is reversed to prevent freezing in the main working shaft (the North Green).

Auxiliary ventilation is provided to blind drifts, raises, and stopes by small centrifugal fans mounted over churn-drill holes at the surface and/or installed along the main air course underground. (See fig. 21.) Buffalo 6E electrically powered pressure-booster fans are used for this purpose. As the workings advance, new holes are often exposed. They, in turn, are used to deliver fresh air to the working face. The fans installed at strategic points along the main airway are connected as blowers to Flexipipe neoprene 8-inch tubing, which delivers air to the face of blind drifts, stopes, and crosscuts. The tubing is purchased in easy-to-handle, lightweight, 50-foot lengths, with special couplings for connection.

FIGURE 21. - Fan Installation at Mining Level of North Green Mine.

The Hill-Ledford mine is provided with controlled ventilation by a 36-inch, two-stage, Axivane high-pressure (10 inches water gage) series 1,000-fan located at the shaft collar. The fan forces air into the mine at a rate of 27,000 c.f.m. through 30-inch Flexipipe (made of neoprene material) hung in the shaft. At the shaft bottom the neoprene tubing is reduced to 24 inches. The tubing is supplied in 50-foot sections with sewed-in couplings and grommets for suspending. (See fig. 22.)

MINE DRAINAGE

The volume of water entering a mine in the Cave-in-Rock area is relatively small compared with the volume handled in the underground mines in the Rosiclare fluorspar area. In the Rosiclare area water handling is a major problem, and pumping has always been the largest single mining cost. Most of this water probably enters the mines from the Ohio River. A water problem

Generated on 2024-09-22 02:46 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

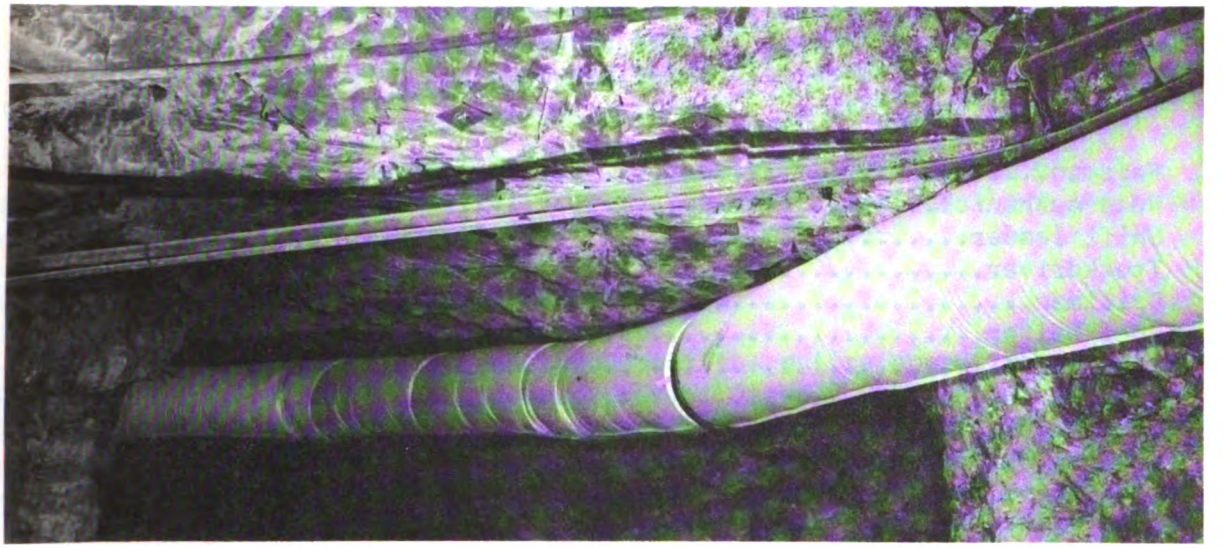

FIGURE 22. - Ventilation Tube Used at Hill-Ledford Mine.

seldom exists in the Cave-in-Rock area, where surface water seeps into the underground mines from beds of streams, sinkholes, and directly from the surface. It is often necessary to obtain additional water for drill or mill use. The volume of water entering each mine varies considerably with the season of the year and the geology and topography of the surrounding territory.

Water that seeps into the North Green mine flows by gravity to a collecting sump at the shaft station. A drainage arrangement consisting of ditches and auxiliary portable pumps controls this flow.

The auxiliary pumps drain the water that collects occasionally at the working face or in mine-floor depressions. Some water seeps through the floor of the mine and drains into adjoining mines or completely away from the area.

A deep-well turbine pump capable of raising from 250 to 300 g.p.m. of water against a hydrostatic head of 440 feet is installed in the shaft. The pump, which discharges into a creek at a point downstream from the shaft, is operated intermittently, depending upon the volume of water entering the mine. A small sump pump keeps an elevated water tank full for use in the drills; any surplus is wasted. The water is obtained from the upstream side of this creek.

WAGES AND INCENTIVE PROGRAMS

The North Green mine generally employs 14 men and 1 foreman to produce about 20 to 27 tons of ore per man-shift. They work from 7:00 a.m. to 3:30 p.m. 5 days a week. Only emergency work is done on Saturday or Sunday. The employees are not represented by a union at this or any of the company's other mining operations in the area. However, the wage scale and fringe benefits compare favorably with those offered by other fluorspar producers in the district. The employees receive a shift differential of $0.05 an hour

Generated on 2024-09-22 02:44 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

for the second shift and $0.08 an hour for the third 8-hour shift when these shifts are worked. The classification and prevailing wage rates are as follows:

Classification:	Base hourly rate
Foreman	$1.97
Head mechanic	1.97
Shift leader	1.92
Truckdriver	1.80
Drillman	1.87
Roof bolter	1.87
Timberman	1.82
Pipeman	1.82
Trackman	1.82
Slusher operator	1.82
Loading-machine operator	1.82
Cager and hooker	1.72
Motorman	1.80
Miner helper	1.72
Hoistman, class A	1.77
Hoistman, class B	1.72
Grizzly attendant	1.62
Mechanic (working foreman)	1.82
Mechanic, class A	1.77
Mechanic, class B	1.72
Electrician (working foreman)	1.82
Roof trimmer	1.82
Student apprentice	1.72

Before November 1954, the Ozark-Mahoning Co.'s mines were operated by contractors. Since that date, hourly employees have been doing the work. Employment of this type has several advantages: (1) Mining costs have not increased proportionately; (2) controls are more flexible; (3) by practicing selective mining and blending the different ores, a more uniform millfeed is maintained; and (4) percentage extraction of the ore body has increased.

An incentive contract was started at the Hill-Ledford shaft sinking project after the shaft was approximately one-third completed. A labor contract allowed $28 per foot of ground removed between depths of 300 and 400 feet and an increase of $2.50 a foot for each additional 100 feet of depth. An additional $10 a foot was paid for necessary timbering. Progress was measured weekly. The shaft crew increased their earnings about 65 percent above the base-pay rate. Sinking time was greatly reduced, thus lowering the overall cost per foot. Sinking and timbering the Hill-Ledford shaft was completed at a cost of $138.64 a foot.

Another contract was started for a 7- by 7-foot crosscut at the Oxford No. 11 mine. The contract price was $8 a foot for the first 100 feet and increased $0.05 a foot for each successive 100 feet. Moreover, necessary slabbing was paid at $0.10 a cubic foot. The company guaranteed a minimum

Generated on 2024-09-22 02:51 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

base pay equal to prevailing daily and overtime wages for the time worked. Power, equipment, and supplies were furnished by the company. The contractors were required to drill, blast, and muck; install air, water, and ventilation piping; lay track; and keep the roof and walls trimmed and the roof properly supported.

Progress exceeded the footage made by hourly employees, cost per foot decreased, and the men substantially increased their earnings above the base pay.

FIRE PREVENTION

Good housekeeping is required throughout the entire operation to maintain beneficial personnel attitude and help prevent fires. Other principles followed that are applicable to fire prevention are proper maintenance of equipment, adequate insulation of electrical wiring, and periodic thorough inspections. All combustible diesel fuel is stored aboveground, and at the start of each shift enough fuel is taken underground to operate the equipment in use for the duration of the shift. Fire extinguishers have been placed at potential danger spots underground and in surface installations. Normally, they are placed in the hoist rooms, repair shops, near electrical apparatus, in timbered shafts, and at other strategic locations.

SAFETY PRACTICES

The company provides protective dress and equipment, also proper lighting, ventilation, and sanitation for the safety, health, and welfare of the workers. Periodically, the Illinois State mine inspector and company personnel use the proper instruments to detect and determine the concentration of noxious gases in general haulage areas, in active stoping areas, and at diesel-engine exhaust ports. Accidents are analyzed and preventive measures adopted because it has been proved a safe worker is more efficient and more productive. Each employee is instructed to work safely at all times. Safety films and talks are presented periodically to teach the worker how to use all tools and equipment safely. Safety posters are placed at strategic locations throughout the mine and mill to continually accent safety consciousness. A scoreboard, which shows the number of days worked without a lost-time accident, is kept at each mine. The men at each mine compare their safety records with that of other company operations and take special pride in having fewer lost-time accidents and in establishing new records.

In 1957 the accident frequency rate was 11 at the company's mines and mill in the area. This rate was based on the number of disabling injuries per million man-hours worked.

Generated on 2024-09-22 02:53 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 1. - Summary of costs, percent of total

Location of mines: Cave-in-Rock fluorspar area Period covered: 1957

	North Green mine	All properties
Drilling and blasting	23.14	10.21
Dead work[1]	.39	.45
Loading	8.20	8.37
Tramming	6.29	6.92
Underground, general[2]	9.71	13.16
Hoisting and dumping	7.50	10.54
Preparation[3]	5.78	3.52
Total, mining operation	61.01	63.17
Mine, general[4]	18.78	17.21
Insurance	2.42	2.30
Taxes	3.33	2.66
Water, power, and light	7.65	9.24
Works, general, and district office expense	6.81	5.42
Total	38.99	36.83
Grand total	100.00	100.00

1/ Development work not charged to mining.
2/ Underground supervision, tools, supplies and repairs to equipment.
3/ Handling of the ore after it is hoisted and dumped and before milling.
4/ All office, staff, travel, exploration, and health expenses.

Generated on 2024-09-22 02:48 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 2. - Summary of costs in units of labor, power, and supplies

Name of mine: North Green
Tons of ore mined and hoisted: 5,741

Period covered: February 1957
Mining method: Open-stope breast stoping with random pillars

	Development and mining[1]
Labor (man-hours):	
Breaking (drilling and blasting)	0.122
Roof bolting	.044
Mucking	.056
Haulage and hoisting	.133
Supervision	.044
Bulldozing[2]	.133
Total underground[3]	.532
Production tons per man-shift	16.3
Power and supplies	
Explosives (40-percent dynamite) lb. per ton	1.2
Total electric power kw.-hr. per ton	14.0
Percent of total labor cost	
Underground	89.69
Surface	10.31

1/ No breakdown available between development and mining.
2/ Grizzlymen's time properly charged to this account.
3/ All labor properly charged to underground operation, except supervision.

U.S. GOVERNMENT PRINTING OFFICE : 1960 O—574790

Generated on 2024-09-22 02:50 GMT / https://hdl.handle.net/2027/osu.32435030643324
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY